Lake Monroe Pilot Watershed Study

EXECUTIVE SUMMARY

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Supported by Indiana Department of Natural Resources and Indiana Department of Environmental Management 319 Non-Point Source Program

Acknowledgments:

The group of studies known as the Lake Monroe Watershed Study is the synthesis and product of many people. Initial energy came from the Governor's Watershed Task Force and Senator Vi Simpson. We owe many ideas and an understanding of the watershed forest community to George Parker at Purdue. Primary research support came from:

Indiana Department of Natural Resources. Our project officer was Jim Ray. We had help from Dave Herbst, Harry Nikides, Rex Watters and Steve Andrews.

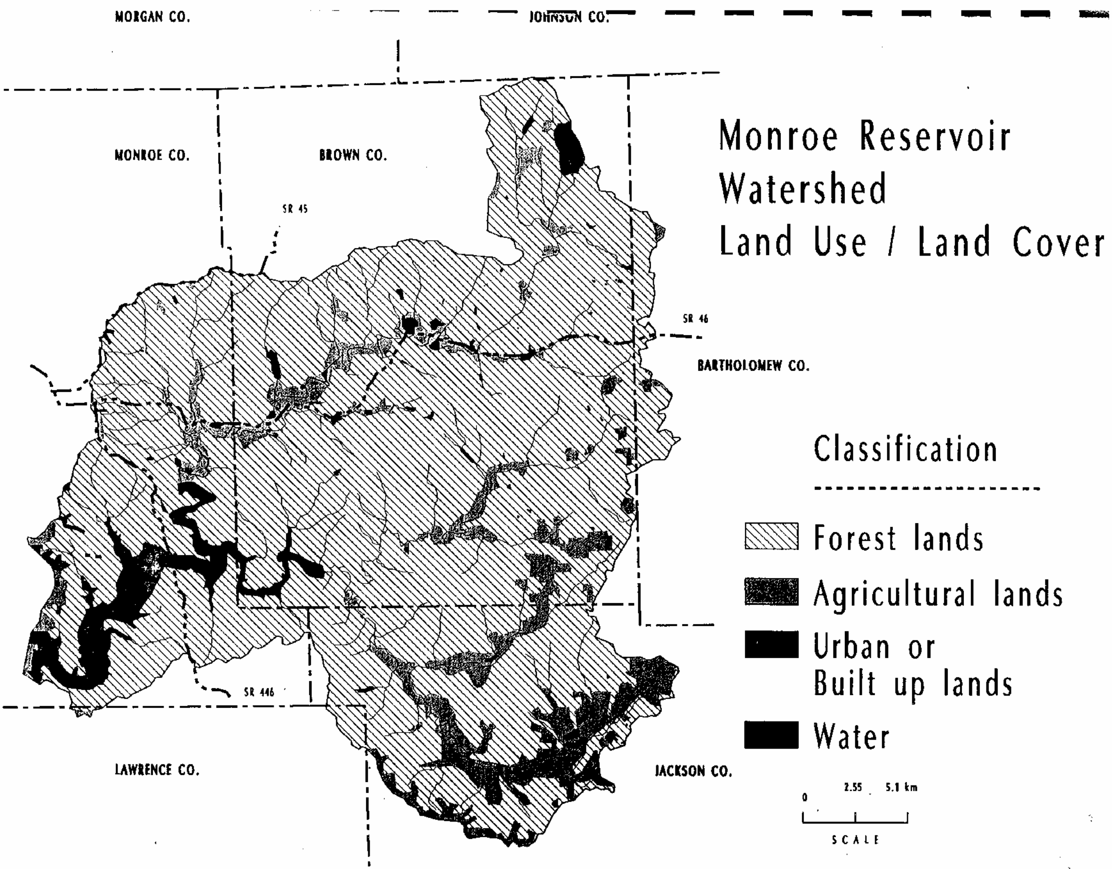
Indiana Department of Environmental Management. Our project officer was Jill Ebner. We are grateful for their help and advice.

Many of our colleagues at Indiana University have contributed with time and expertise. J.C. Randolph and the Midwest Center of the National Institute for Global Environmental Change, particularly, the Geographical Information System Laboratory has supported us with facilities and ideas. Jeff Ehman from the GIS laboratory helped us with the mapping. We depended on the Lake Monroe Diagnostic Study done by Bill Jones and his students. We learned from the past work of the late Dave Frey and his students. Don Whitehead and his students kept us posted on Neotropical Migrants in the watershed. Josep Mallarach taught us all photo interpretation.

Tim Tilton, Joyce Polling and Norman Anderson of the Monroe County Council provided resources to do detailed GIS mapping of the Lake Monroe/Monroe County Watershed. Kevin Buckheit of the Monroe County Planning Department helped facilitate data acquisition. We thank Susan McCloud of the USDA Natural Resources Conservation Service for her support and advice. Ben Beard of Gentry Real Estate provided insights into the development prospects for Monroe County. Bill Hayden gave the environmental communities view. Rob Fuller from the Louisville District Corps of Engineers, Don Brady from USEPA, Jon Kusler from the Association of State Wetland Managers and Kevin Erwin from Erwin Ecological Services all helped us think through the processes of watershed management.

Hundreds of students have put thousands of hours working on the Lake Monroe Watershed in classwork. Many have worked specifically on this project:
Rene' Auborg, Melina Kennedy, Nathanial Lloyd, Jennifer Maio, Dina Snow, Shana Weber, Eric Beer, and Nancy Eslick.

Karen Stephens, with help from Heather Almeter, facilitated the assembly and presentation of this report.


Monroe Reservoir Watershed Land Use / Land Cover
MORGAN CO.
JOHNSON CO.
MONROE CO.
BROWN CO.
SR 45
SR 46
BARTHOLOMEW CO.
SR 446
LAWRENCE CO.
JACKSON CO.
Classification
Forest lands
Agricultural lands
Urban or Built up lands
Water
0
2.55
5.1 km
SCALE

Lake Monroe PILOT WATERSHED STUDY[1]

Dan Willard and Avram Primack, INDIANA UNIVERSITY.

Chapter I. Executive Summary

I. INTRODUCTION

The Indiana Governor's Watershed Management Task Force authorized **The Lake Monroe/Salt Creek Pilot Watershed Study** in 1993. The study is a cooperative and applied effort between the Indiana Department of Natural Resources and the Indiana Department of Environmental Management. The Task Force charge was:

***Maintain and improve water quality throughout the watershed.**
***Encourage economic development on appropriate sites.**
***Maintain and enhance biodiversity.**

The program uses the Lake Monroe Watershed [see previous map] as a practical application to establish both methodologies and criteria for assessing, managing, and monitoring water quality at a watershed scale. Techniques developed by this program will apply to other watersheds through integrated watershed management and promote better watershed maintenance practices through improved watershed use practices.

II. WATERSHED MANAGEMENT

A. Background

1. Integrated Watershed Management in General

The Lake Monroe Pilot Watershed Study develops and tests a method for managing the watersheds of Indiana. The study has two parts: first we report on the methodologies and criteria for assessing, managing, and monitoring water quality at a watershed scale. Techniques developed by this program may be applied to other watersheds through integrated watershed management and to promote better watershed maintenance practices through improved watershed use practices. Second, we applied the method to the Lake Monroe/Salt Creek Watershed as a practical application of the methodologies and criteria for management.

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[1] Supported by Indiana Department of Natural Resources and Indiana Department of Environmental Management 319 Non Point Source program.

The Pilot Watershed Study consists of three interlocking parts: understanding the consequences of historic environmental change, experimental manipulation of watershed elements and documenting the social, legal and jurisdictional conflicts that retard wise watershed ecosystem management. These parts taken together yield the interdisciplinary analysis that will guide us to the elements of a statewide integrated cooperative management program.
The goals and products of the integrated project are:

1. **To understand the biological, physical, and chemical capacity of the watershed.** We need centralized, systematic, data bases consisting of historic and recent data. From this we must elucidate the dynamics of Indiana watershed ecosystems sufficiently well so as to predict the consequences of management activities. We must identify potential ecosystem restoration opportunities which will enhance and sustain the human support systems of our watershed ecosystems into the next century.

2. **To understand human demands and impacts of the associated resource conflicts upon the watershed ecosystem now and in the future.** To develop this understanding we must: a) provide for public participation and consensus building, b) identify, evaluate and rank issues, c) develop educational programs to create a community awareness of watershed issues, d) identify the interests of the affected parties, e) suggest methods of coordination among concerned local, state, and federal agencies.

3. **To develop adequate management tools to adapt our social needs to our resource capacity.** This will require that we a) develop an interdisciplinary capacity among managers, b) identify and rank watersheds for future consideration, c) document the available regulatory tools, d) suggest new legislation, if necessary, and e) suggest potential restoration sites.

B. Data Base

1. Need for Reliable, Accessible Data

Watershed management involves geographic areas large enough to require extensive, multi-disciplinary data sets organized to provide information for decision-making. Data must be organized differently if the goal of the analysis is water quality modeling, land management, or gap analysis. The watershed approach used by this project demands that the data meet all these needs. Further, the information must be accessible and useful to non-technical public decision-making bodies. Only a large, fast, technically complex, computer system with adaptable operators can manipulate and display the needed information in a timely way. The system is only as good as the data in it. The greatest impediment to large scale landscape planning and management, such as watershed management, is the availability and accessibility of reliable data at the suitable scale.

The largest use of our financial resources on this project relate to the costs of acquiring, correcting, and organizing data[2]. Even so, many people in the GIS Laboratory, in state and federal agencies and in Monroe County government gave considerable free help to the project. Similarly, many faculty members gave advice and help.

One of the main difficulties with modeling large areas for sediment and nutrient sources is that as the area to be modeled increases the data requirements also increase. There are two solutions for this problem: 1) find a way to treat the larger amount of data, or, 2) treat the data in a coarser manner so resolution of input data and the results become less well defined. Also, testing different land use scenarios at large scale requires a large amount of restructuring of the data. Geographic information systems (GIS) databases are a convenient tool for integrating large amounts of spatial data and are increasingly being used for non-point source pollution and watershed modeling[3]

2. Erosion and Nutrient Modeling using GIS Based Technology

We constructed a database using Arc-Info, at the Geographic Information Systems Laboratory at the School of Public and Environmental Affairs (SPEA). GIS links spatial coordinates with a variety of databases and a graphic display. It allows the user to ask questions about the spatial relationship of elements in the database and reorganize the database into different forms. In this case, we used the GIS to overlay layers of information from different sources so that we could build a database containing information that we could output to an erosion event model.

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[2]Many of the technical and field people were students and worked at nearly minimum wage.

[3] Cahill *et al.* 1994, He *et al.* 1993, Lo 1994, Morse *et al.* 1994, Smolen 1993, Srinavasen and Arnold 1993, Tim *et al* 1990, Tim and Jolly 1994, Tim *et al.* 1992, Vieux 1993, Warwick 1994.

We choose to use the Agricultural Nonpoint Source Pollution Model (AGNPS) developed by the United States Department of Agriculture (USDA) at the agricultural research station at Morris, Minnesota (USDA-ARS 1994) because it is relatively easy to use.

1. Data sources

a. Land Use- Detailed land use maps at fine scale do not exist for the Lake Monroe Watershed. We constructed those for the test subwatersheds from the intensive analysis of low level aerial photography.[4]

b. Soils- We constructed our own data base from existing sources. In the future, corrected soils maps should be available for most parts of the state.

c. Digital Elevation Models (DEM)- Elevation models are a digital representation of the information contained on the elevation lines of a contour map. We obtained DEMs at the 1:24,000 scale (the scale of USGS 7½ minute topographic maps) .

One of the goals of the Pilot Watershed Study was to determine the availability and effectiveness of existing landscape data for purposes of watershed planning. The initial plan assumed that existing remotely sensed data would suffice to provide usable information for planners and managers. These managers need, among other things, the ability to model soil erosion and nutrient movement. While the available images do provide an adequate base map, considerable additional work is required to use the existing images for water quality management and to prepare interactive materials. Current soils maps are not available. Data must be corrected through a digital elevation model [DEM]. Land use evaluation requires finer grained accuracy than is directly available through satellite images. Thus we proposed four low level aerial photographing trips to provide material for landuse mapping. Ultimately we flew two flights and borrowed the images from the forest service for one flight. We canceled the spring 1996 flight because abnormally high water obscured the lowland information we sought.

There are several methods for constructing DEMs. These include digitizing contour lines and interpolating elevation data between contour lines

[4]Done by Josep Mallarach

(hypsography), and interpolation using aerial stereo photographs. DEMs can also be created by interpolation of data points into data from a large scale (1:250,000) DEM to create a smaller scale DEM (1:24,000). All of these methods have the potential for introduced error, and DEM data should be checked against other data before use. Generally, hypsography gives the best results in regions with high rates of relief, but does poorly in flat areas where contour lines are far apart and not parallel to one another. Where lines are far apart and not parallel, computer interpolation routines may use the same contour line for interpolation to itself creating a flat region. Interpolation from aerial photographs is limited by the skill of the interpreter. On occasion, unskilled interpolators may use the tops of trees as the ground, introducing errors equal to the height of the trees. DEMs created by scaling down large scale DEMs to create small scale DEMs really contain information still at the large scale. This procedure does not add in the small scale variations in relief that were not present in the original large scale information. We checked our DEM for accuracy by comparing slope as reported by the DEM to slope as reported by soil type.

C. Public Workshops, Meetings and Education

The Lake Monroe/Salt Creek Pilot Study contained provisions for public education and outreach an essential part of any watershed effort. Watershed management can not proceed unless there is strong, coordinated and informed local support. Our role was to provide useful, responsive technical support in the form of information and analysis. We found information-rich custom-designed GIS based maps very effective in focusing and accelerating public decision-making. These activities required immense time commitments.

We sponsored and presented a public workshop in the spring of 1996. This is an ineffective way to establish watershed based thinking and management, because most concerned citizens have jobs and families which do not give them the time to attend a day long or longer workshop. We believe that it is more important to reach out to the clients or stakeholders at times and places convenient to them, rather than formal day-long workshops. Rather, we choose to work with existing groups, give talks in a variety of venues around the watershed, any where some expressed an interest. Even at that, we did not have the time or resources to devote full time to supporting watershed management and testifying as do paid lobbyists for other viewpoints.

Project personnel participated in the Salt Creek Alliance and Lake Monroe Watershed Task Force meetings on several occasions. We taught 11 high school and middle school classes. We served on and participated in 12 Department of Natural Resources Bureau of Water and Regulation Advisory Council Meetings. We served on the Governor's Interagency Watershed Committee. We presented working papers from our watershed management work at 4 National Conferences. We served on and participated in the Monroe County Overlay Committee which developed and planned the Lake Monroe Overlay Ordinance now before the Lake Monroe County Commissioners. This workshop/meeting was open to the public and seen widely on Bloomington Cable Access Television [BCAT]. We met over twelve times for 3-5 hours each time. We took a full working day to prepare maps and data at the request of the committee for each meeting. We recognized IDEM's 319 project on all the maps and documents.

D. General recommendations for a Watershed Management Program

1. Managers need a method to acquire existing data about the watershed, determine its value and develop additional data, if needed, to make technically sound decisions. Some states have a State Geological or Biological Survey. **We recommend the establishment of a State Natural Resources Data Center to create an adequate data base.**

2. Managers need a system to integrate these data, and make the information available to the public decision-making bodies on an interactive basis. We used Indiana University School of Public and Environmental Affairs Geographic Information System [GIS] as the integrating tool. **We recommend the establishment of a State-wide Natural Resources GIS to provide for the needs of watershed managers across the state.**

3. Many opportunities exist for public and private cooperative watershed improvement and restoration. Watershed managers should aggressively pursue opportunities with private corporations such as foresters, developers and farmers working with IDNR, NRCS, US Fish and Wildlife Service, the USA Corps of Engineers, and the US Forest Service. **We recommend an interagency clearing house for watershed management.**

4. Integrated watershed management requires watershed-wide political cooperation. Government technical support and funding are most available if there is clear public support. This support should be multilateral and include a broad array of stakeholders. Watershed-wide local groups are essential to reach socially integrated goals. Watershed support groups must be focused on the whole watershed across political boundaries. **We recommend legislation that enables the formation of watershed districts to solicit funds and promote watershed management programs in the watersheds of Indiana.**

5. Watershed management programs should include policies guiding and supporting a broad array of land use, development, protection and restoration activities. These programs contain both incentive programs and regulatory programs. **We recommend that mitigation banks and restoration activities be part of any watershed management program**

III. THE LAKE MONROE/SALT CREEK CASE STUDY

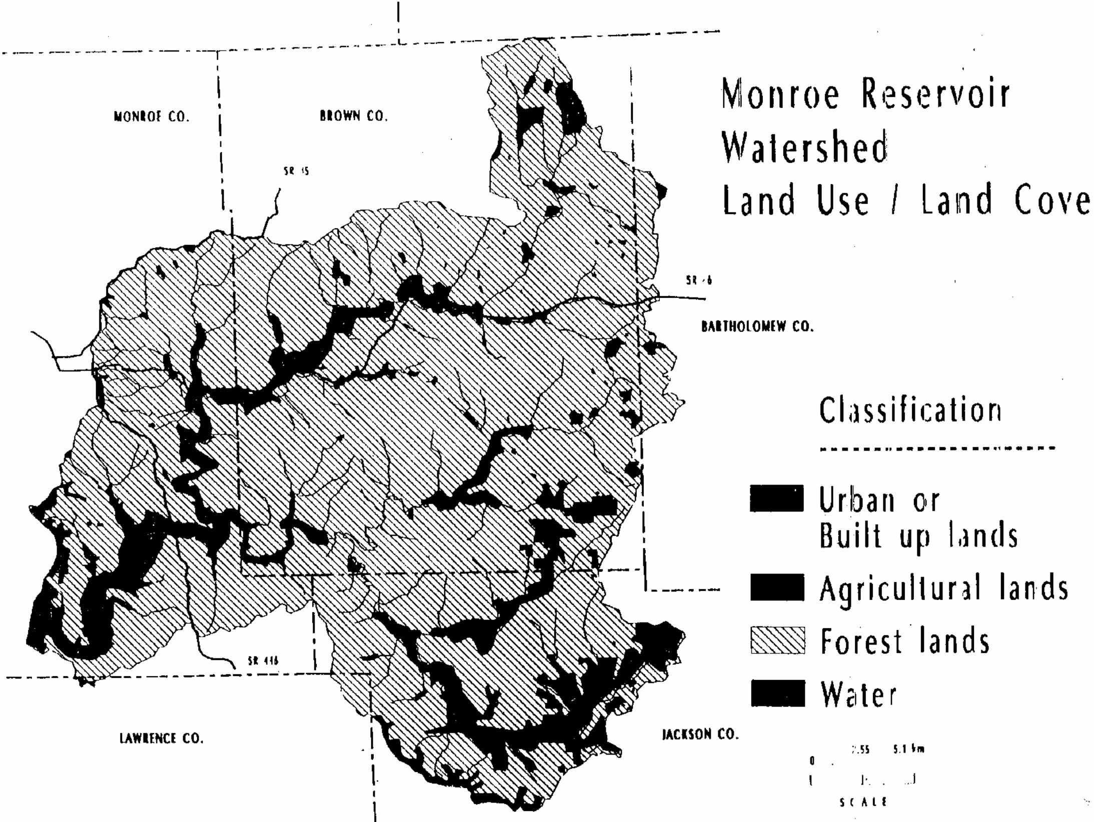
A. Background

1. About the Lake Monroe/Salt Creek Watershed

Monroe Reservoir designed and constructed by the U.S. Army Corps of Engineers under the 1958 Flood Control Act was completed in 1965. Today, Lake Monroe supplies drinking water to the City of Bloomington and eight rural water companies. It provides flood control, recreational areas, and wildlife habitat for south and central Indiana. Lake Monroe's watershed includes parts of five counties: primarily Monroe, Brown and Jackson counties, and secondarily, Lawrence and Bartholomew counties. Monroe Reservoir, at its normal pool level of 580 feet, has 10,750 surface acres. Lake Monroe has a maximum depth of 54 feet, a mean depth of 17.3 feet, and a residence time of 242 days. During the flood of 1996 the lake reached a level of 554.9 feet, almost 17 feet higher than pool elevation. At that time the lake volume was more than doubled. Forest covers approximately 90% of the watershed's 441 square miles land area. This includes parts of the Hoosier National Forest (78,000 acres) and Yellowwood State Forest (40,000 acres). Nine recreational areas and one larger community (Nashville) occur in the watershed. Originally built for flood control, today the lake is the most important recreational area in southern Indiana, attracting visitors year round. In 1989, Lake Monroe had 1.5 million lake visitors who added approximately $150 million to local economies. Visitors are attracted by the lake's ample public access through three state recreational areas, the Hoosier National Forest recreational area, two state wildlife refuges, and ten public boat ramps. The Lake Monroe Diagnostic Study, various agency studies, and several years of graduate environmental chemistry studies have not shown any chemical contaminants of concern in Lake Monroe.

The Lake Monroe Pilot Watershed Study combines the capability of Geographic Information Systems and Ecosystem Modeling to the accuracy of precise field work and constant interaction with local government, private citizens, public schools and the relevant federal and state agencies. We have mapped and

Monroe Reservoir Watershed Land Use / Land Cover



analyzed the entire watershed the broad scale. Detailed GIS mapping, aerial photography analysis, and field checking and analysis is 90% complete for Monroe County. The field work for the near watershed in Brown and Lawrence Counties is 10% complete and in the GIS Data Base. These intensively studied areas provided the information base for the data and observations discussed below. This study contains complete and detailed mapping and interdisciplinary analysis for the near watershed, particularly those areas in public hands.

This analysis has helped select the most suitable places:

a. for economic development,

b. for mitigation sites that preserve and protect the water quality of streams and lakes from the consequences of economic activity,

c. enhance and restore areas to increase habitat for biodiversity

d. correct some of the problem areas to water quality caused by past human use.

The application of the watershed management concepts to the Lake Monroe/Salt Creek Watershed allowed us to attempt model to soil erosion and nutrient movement in selected subwatersheds to test vulnerability to above and the mitigating effects of stream buffers. This application used two sub-watersheds as reference sites. It depended on field observations in two selected sub-watersheds: 1) Stream Surveys in Stephen's Creek, 2) Stream Surveys in Ramp and Moore's Creeks.

In the Monroe County portion of the watershed, the results of the study will be used to develop a mitigation bank as a portion of the new county zoning ordinance. In cooperation with the COE and the Indiana Department of Natural Resources we have begun several experiment restoration projects in the watershed. These sites will provide information that will improve the design of approximately 17 more such sites around the reservoir.

Indiana Department of Environmental Management and Monroe County have completed the Lake Monroe Diagnostic Study and will continue to monitor the consequences of the restoration projects. Thus we can improve and adapt future restoration. A second IDEM 319 project is coordinated with Natural Resources Conservation Service to determine streamside restoration projects on the many feeder streams. This portion of the effort focuses on small scale water quality improvements on streams and ditches in Jackson and Brown Counties.

B. Findings

1. Over 80% of the Lake Monroe Watershed is forested land. The upland watershed is almost universally covered by shallow easily eroded soils with some areas of karst. Because the upland portion of the Lake Monroe Watershed is heavily forested, these portions of the watershed do not presently contribute much adverse sedimentation or pollution to the lake and streams. However, septic systems generally function marginally in the sloping and shallow soils of the watershed. Thus built-up areas such as the Ramp Creek Subwatershed and the Fairfax Peninsula have higher contributions of nitrogen, phosphorus and other pollutants than do the less developed subwatersheds.

> **This suggests that building and land use controls are necessary to prevent future problems.** The attached Monroe County Overlay Zone Plan provides a model for these controls. It further gives planners the opportunity to determine the most effective restoration sites.

2. The lake and the streams are very flashy and seasonal. Lake Monroe rises at least 10 feet most years and as much as 17 feet this last spring. Many of the streams become dry or stagnant in late summer. This seasonal variability aggravated the sediment and erosion problems of the watershed streams, and of Lake Monroe. Thus it appears that the majority of the sedimentation into Lake Monroe and the streams that flow into it comes from the lakeshore and riparian corridors of the watershed. These sediments are already in the bottoms and so do not show up in sedimentation models based on upland characteristics. These lowland areas are perturbed primarily by agricultural land tillage practices. Portions of these lands are managed by IDNR, others are private. Those areas with no till practices and buffer strips erode less than those without. Observations during the high water periods show that:

> a. Many streams that enter watershed through heavily forested corridors carry little sediment.
>
> b. Those shore lands and streamside areas which contained permanent and complete vegetation of any sort remained clear when flooded. Conversely, plowed areas when flooded were covered with suspended particulate matter. Once suspended these areas stayed turbid for weeks.

c. Several construction sites in the upland had muddy runoff into nearby streams. When these runoff streams passed over vegetated areas, the downstream flow had much reduced sediment load.

The observations on sediment flow patterns are strengthened by the observations from low-flying airplanes that indicate the presence of marked sediment plumes coming from the North, Middle and South forks of Salt Creek as they enter Lake Monroe.

This suggests:

a. That protection and restoration are needed for these bottomland areas. These programs should seek to stabilize stream banks and increase bank storage of flood waters. A variety of incentive programs exist from the Corps of Engineers, Natural Resources Conservation Service, US Fish &Wildlife Service, and private organizations to help promote and pay for these programs. In most cases a restoration plan is necessary with support from local government before entering these programs.

b. That strong support should be given to designing and implementing Best Management Practices for Forestry and Agriculture in the bottomlands along watercourses. These should include adequate buffer strips, no-till practices and reduction of artificial drainage systems. Timber cutting should avoid altering streams, seeps and springs.

3. During summer months turbidity in Lake Monroe increases because of wind and motor boat driven wave activity. Usually the Lake is down to its pool elevation about 538 Ft above mean sea level (amsl) by Memorial Day exposing large areas of unvegetated highly erodible sloping banks. Summer also shows the highest level of algae growth. Jones[5] suggests that nutrients are available to support even greater algae growth if the suspended sediment did not occlude light. Several observations are important to support the later conclusions:

a. High wind against bare banks causes a wide band of suspended sediment along the banks. When the wind shifts these bands of sediments once suspended move across the lake as an organized unit. The 1996 spring floods raised the water level into the vegetated bank. Winds had little effect on the soil and the bankside water remained clear. After the water level fell, exposing unvegetated banks, the wind mobilized considerable sediment.

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[5] W.W. Jones, et al. 1996. *Lake Monroe Diagnostic Study.*

Many existing rip-rap banks do not extend down to pool elevation. Thus, during summer at low lake levels they are ineffective for reducing turbidity caused by intense motor craft traffic and thunderstorms.

b. Many recreational motor boats use Lake Monroe. Weekends during summer have the highest use. Waves created by these boats also erode exposed banks and cause increased suspended sediment in the lake. Observations from low flying aircraft show that motorboats resuspend the bottom sediments behind them as they pass over shallow bottoms. This is particularly obvious in the upper pool east of the SH 446 causeway. Secchi disc depths decrease from 4-5 feet in the near areas to a foot or less over the weekend, and clear again somewhat by Wednesday. In the fall the clarity of the reservoir increases steadily after Labor Day.

A number of areas on Lake Monroe have seasonal watercraft operation restrictions and exclusions at present. For example, the wildlife areas are closed during winter and no wake zones exist on Moore's Creek and along Fairfax Beach. During the May and June high water of 1996, the various markers are not visible or, in some cases, even established. Boaters, including fisherman and personal watercraft traveled at high speed over many flooded areas destroying vegetation, disturbing breeding fishes, and creating erosion channels in the flood plain.

Watercraft cause the greatest portion of the in-lake resuspension and disturbance of sediment. Boat restrictions may take two forms:

i. Lake managers could, if given the authority, limit the size or power of the watercraft. Many lakes in Indiana have electric motors only, or less-than-9-horsepower rules now. These regulations are easy to interpret and simple to enforce.

ii. Lake managers could restrict operation by limiting wake or speed of operation in sensitive areas. These rules are much harder to enforce.

These observations suggest that:

1. **Opportunities exist for new and extended bank stabilization projects in the lake west of the causeway.** Bank stabilization now occurs on many points and exposed shores. Generally the more erodible banks are protected. Clearly, reservoir managers can not protect all banks. In particular all banks and points near docks and ramps may require extending deeper into the

reservoir and further along the banks. Many banks appear to have stabilized with the prevailing wind pattern. While sedimentation can be reduced a little in this manner, much has been done already.

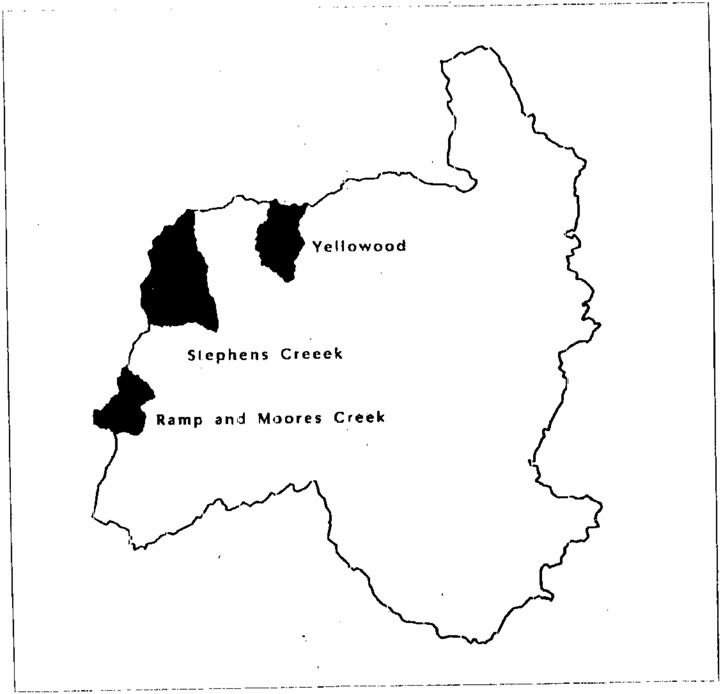
2. We recommend stronger restrictions on the size and operation of watercraft on Lake Monroe. Motor size should be limited to 9 HP or less from the east of the causeway to the western edge of the Middle Fork Refuge. From the western edge of the Middle Fork Refuge upstream boats should be limited to electric motors only. Similarly, the North fork upstream of the Pine Grove Ramp should be limited to electric motors only. The no wake zones at the dam, Moore's Creek, Ramp Creek, Hardin Ridge, Paynetown, Allen's Creek, Sugar Creek, Jarrell/MIller/Martin Creek and elsewhere should be maintained and enforced year around. The no wake zone at Fairfax should go from the low water tip of the point extending toward Hardin Ridge to the low water tip of the point just south of the Fairfax Ramp.

4. Water quality, recreation, economic development, biodiversity and general quality of life will be improved in the Lake Monroe/Salt Creek Watershed through the development of mitigation and restoration areas. Gap analysis and our land use analysis shows that several opportunities exist for the creation of a watershed mitigation bank and restoration area.

Findings:

Gross analysis of landuse and erosion potential point to the sediment laden corridors of the North Fork and South Forks of Salt Creek as the first priority mitigation and restoration areas.

We recommend the establishment of contiguous forested buffer areas, permanent vegetation, and bank storage areas along these watercourses both within the reservoir COE line and on public and private land outside. These will provide the greatest benefits for water quality improvement, reducing flood damage and promoting fisheries and wildlife habitat.

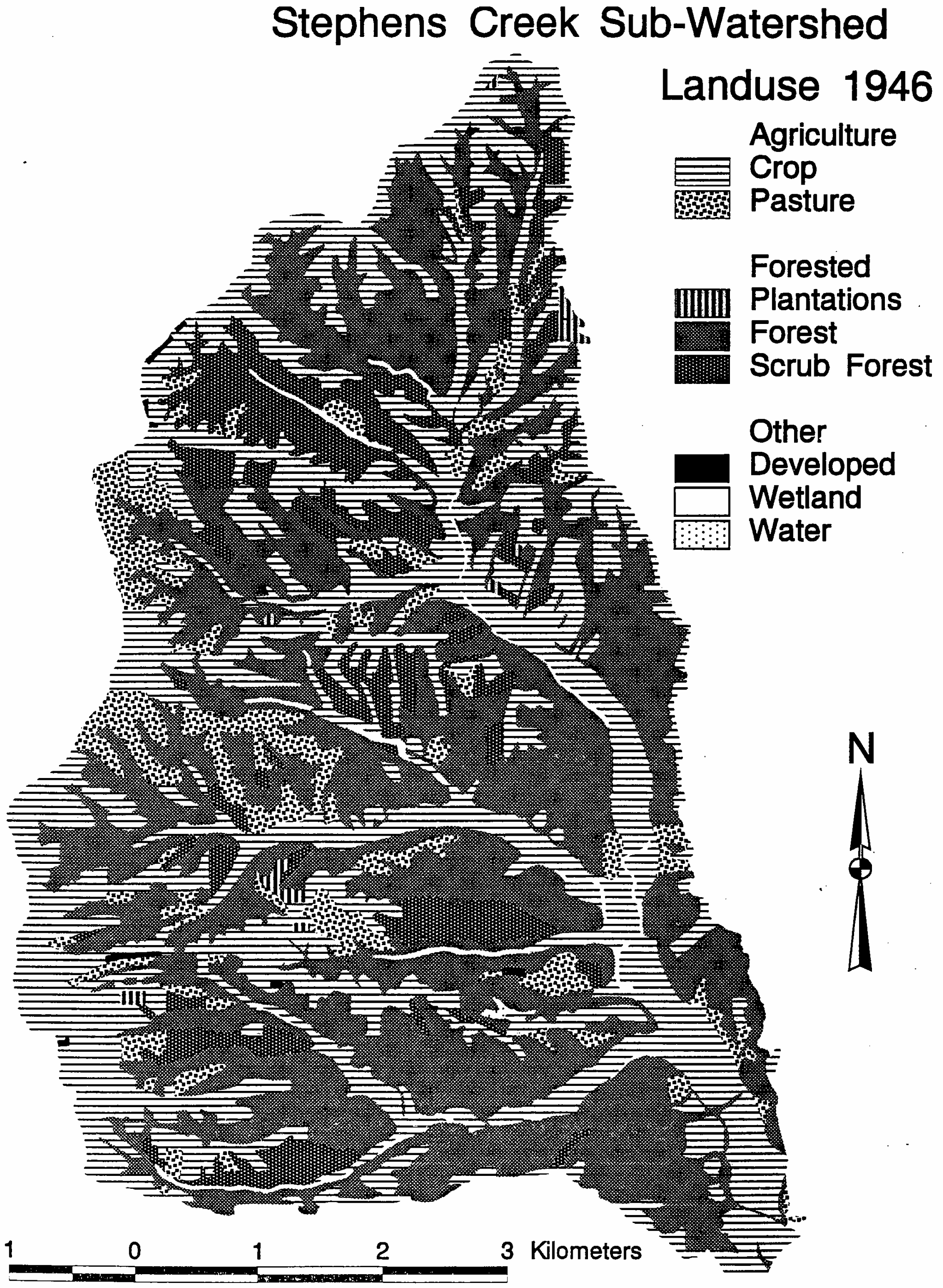


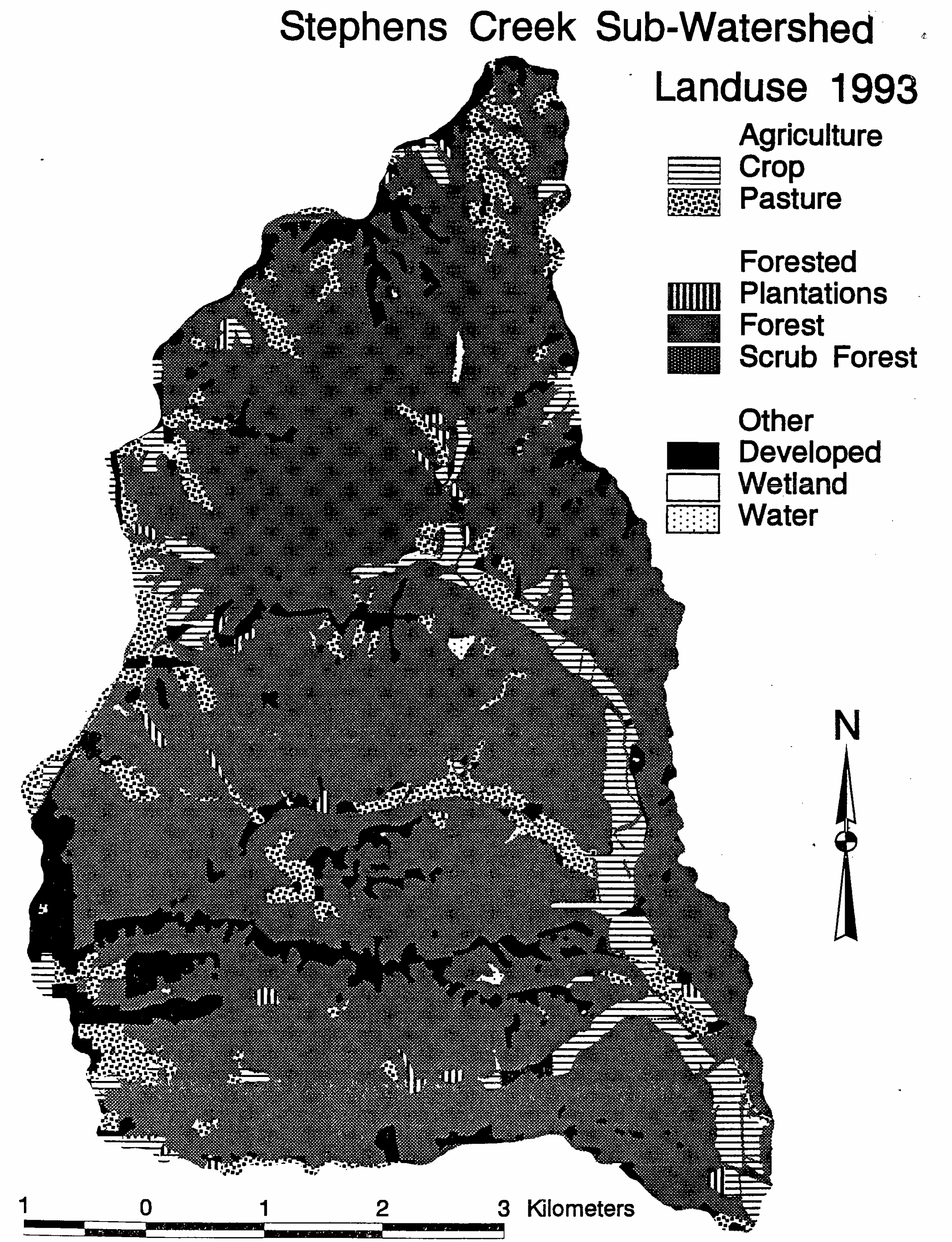
Lake Monroe Watershed

Pilot Study Watershed Locations

0 miles 1 2

SCALE 1: 65000


Stephens Creek Sub-Watershed
Landuse 1946
Agriculture
Crop
Pasture
Forested
Plantations
Forest
Scrub Forest
Other
Developed
Wetland
Water
N
1 0 1 2 3 Kilometers


Stephens Creek Sub-Watershed
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